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TES Measurement of CO

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1- JPL, 2 - LaRC, 3 - U.Denver, 4 - AER, 5 - Raytheon

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1. Introduction

- Originated mainly from combustion of fossil fuels and the combustion of biomass, tropospheric CO plays an important role in tropospheric chemical and dynamic processes. CO is the primary sink for OH radicals and a precursor to ozone with an average lifetime of 2 months. CO is therefore a good tracer for intercontinental transport. Substantial amounts of atmospheric CO are also produced by incomplete oxidation of methane and other hydrocarbons. TES measures tropospheric ozone, CO and CH_4 at same geolocations and times.

- TES is a high spectral resolution infrared Fourier transform spectrometer on the Aura satellite. In 1-day-on / 1-day-off global survey mode, TES makes measurements at nadir and rear-looking limb respectively; In special observation mode scheduled on "off" days, the nadir observations are made.

  TES 16-pixel footprint dimension at nadir: 5x8 km.
  TES vertically stacked 16 pix at the limb tangent: 23km wide x 33 km height.
  * Pixel 1 for 1A1 (the 2nd from bottom at limb) was disabled.

- The following optical filers are used in nadir and limb observations.

2B1	1B1	1B2	2A1	1A1
650-930 cm^{-1}	810-1060 cm^{-1}	920-1160 cm^{-1}	1090-1350 cm^{-1}	1890-2260 cm^{-1}
nadir/limb	limb	nadir/limb	nadir/limb	nadir/limb

  Measurement in filter 1A1 is used to retrieve CO. This retrieval step is after the steps of retrieving atmospheric temperature, ozone etc. from measurements in the other filters.

- Since launch on July 15 and the first mini-global survey measurements on Aug. 22, 2004, TES has performed five de-ice cycles to remove the ice-build-ups on the detectors every 10-20 days. A few days global survey and some special observation data were collected during each cycle.

- TES Level 1B effort of deriving radiometricaly calibrated spectra has been focusing on nadir spectra for filter 1A1. In this poster, we will present some updated L1B spectra for 1A1 in typical times and geolocations.

- The preliminary TES Level 2 retrieval algorithms have been tried on a few special observations and global survey data for CO retrievals. We will present some results and the retrieval characteristics.

- As an initial effort of validating TES CO retrievals, the limited TES CO data were compared with MOPITT CO products and the GEOS-CHEM model results.

2. Sample Calibrated Nadir Spectra for Filter 1A1

Two sample L1B spectra and their noise equivalent source radiances (NESR) expressed in brightness temperature (NEΔT) are shown here. They are from the TES global survey measurement taken on 2004-09-20.

- They are the averaged spectra for 2-nadir scans and all focal planes, respectively.

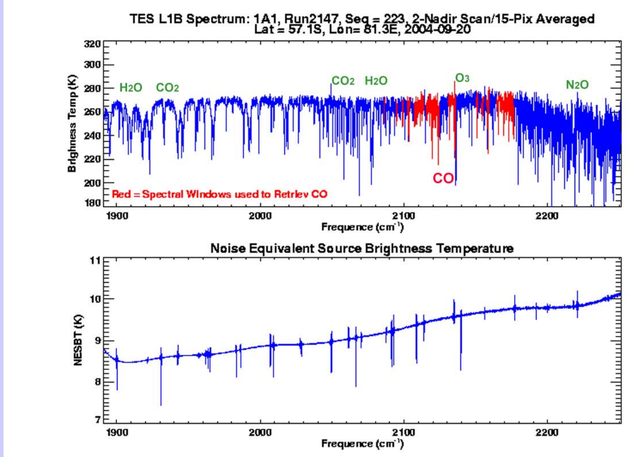
- The signal to noise ratio of filter 1A1 is sensitive to the instrument alignment with the ice buildups as the secondary factor. TES team is closely monitoring the changes in the signal strength of this and other spectral bands and performing de-icings.

- Spikes appear in L1B spectra due to unequal sampling steps of neighbor filters. These spikes are flagged in NESR data array. About 5% spectral points are spikes in filter 1A1.

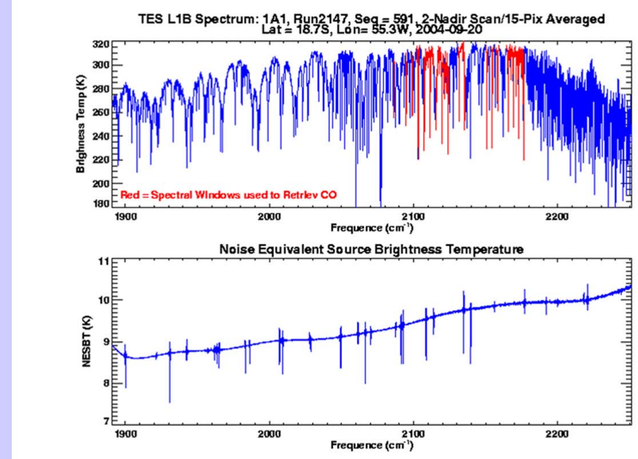
- Currently, L1B has difficulty in processing targets with high clouds (low temperature) and those over ice/snows. Those spectra are therefore rejected via the L1B quality flags.

- The spectral windows used for CO retrieval are shown. They were selected to avoid interferes of the other species in CO retrievals.

(1) Run = 2147, Seq = 223.
The spectrum taken at a near clear sky condition in the ocean near Antarctica. Detailed location is shown on the next poster page.



(2) Run = 2147, Seq = 591.
The spectrum taken at a hot spot of biomass burnings in S. America. Detailed location is shown on the next poster page.

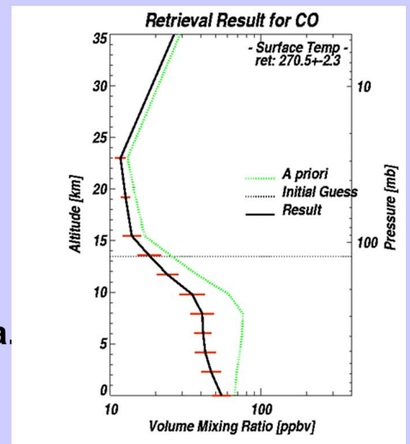


3. Nadir CO Retrieval Characteristics

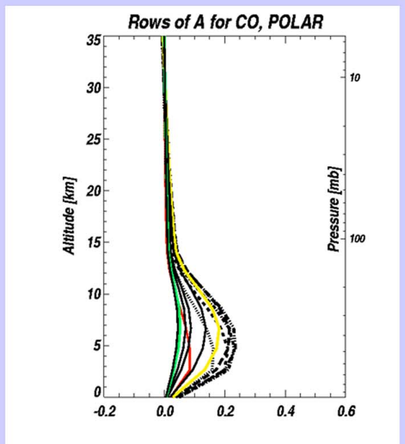
(1) Run = 2147
Seq = 223.

Near clear sky.
Ocean scene
near Antarctica.

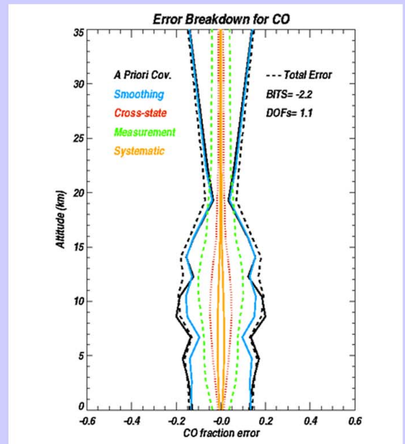
InitGuess/A Priori & Retrieved Profiles



Averaging Kernel



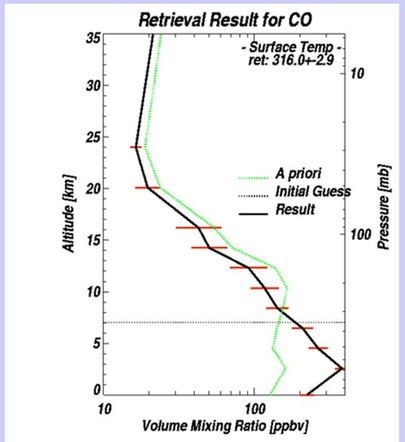
Retrieval Errors Breakdown



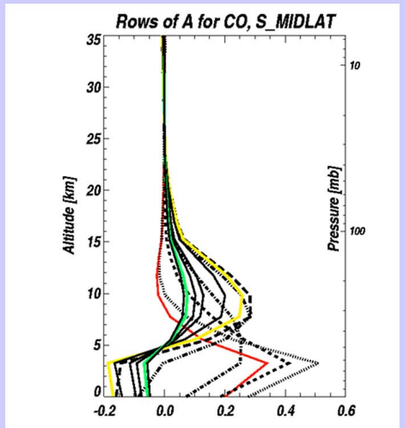
(2) Run = 2147
Seq = 591.

Biomass
burning area
in S. America.

InitGuess/A Priori & Retrieved Profiles



Averaging Kernel



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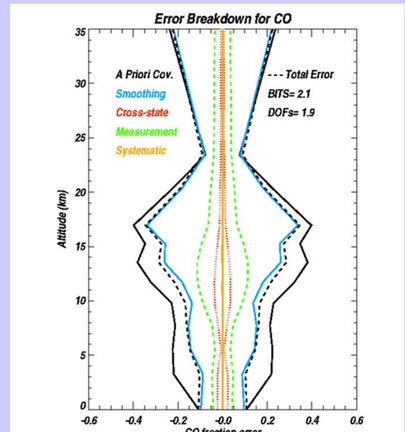
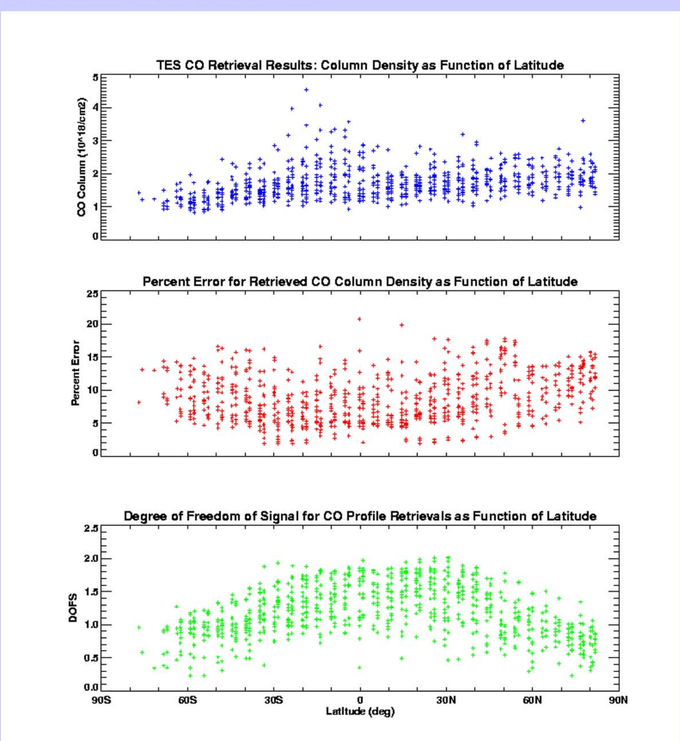


Quantities as function of Latitude for Run 2147, the Global Survey measurements taken on 2004-09-20:

- CO column density, with enhancement occurred in the tropical biomass burning regions of S. America and Africa.

- Percent Error for the CO column with global mean = 8.7%. The larger errors occurred where scan/pixels were rejected due to present of clouds.

- Degree of freedom of signal (DOFs) for CO Profile retrievals. DOFs varies with latitude, ranging from 0.5 and 2. DOFs is anti-correlated with the error.



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Luo, M. and C. Rinsland *et al.*, Page 2

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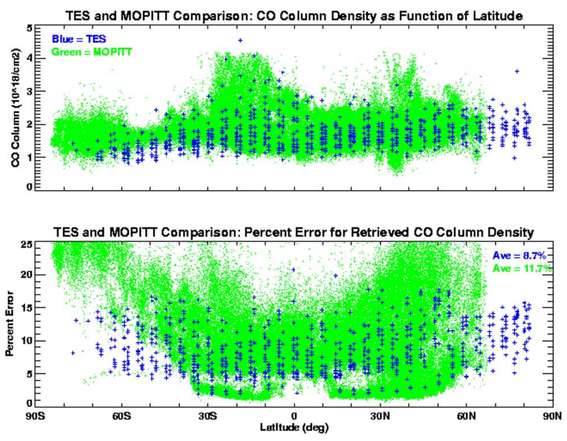
4. Preliminary Comparisons

TES Global Survey CO data for 2004-09-20 is used for comparisons with the CO products from MOPITT instrument, a nadir-looking correlation radiometer on the Terra satellite. We present here only the CO column densities. The model results from the GEO-CHEM are also shown for quantitative comparisons.

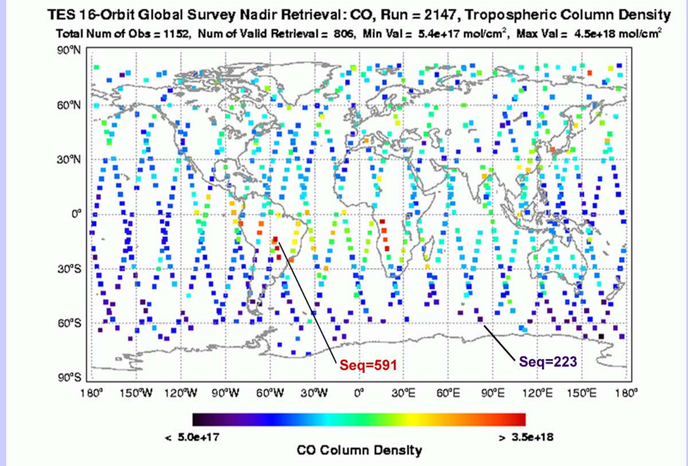
TES and MOPITT CO Column Comparisons:

(1) Top panel: CO column density (mol/cm^2) as function of latitude for both instruments. Number of valid observations for TES and MOPITT are 806 and 159195, respectively. Latitudinal distribution, trends, and the biomass burning peaks are shown in both data set and they agree well.

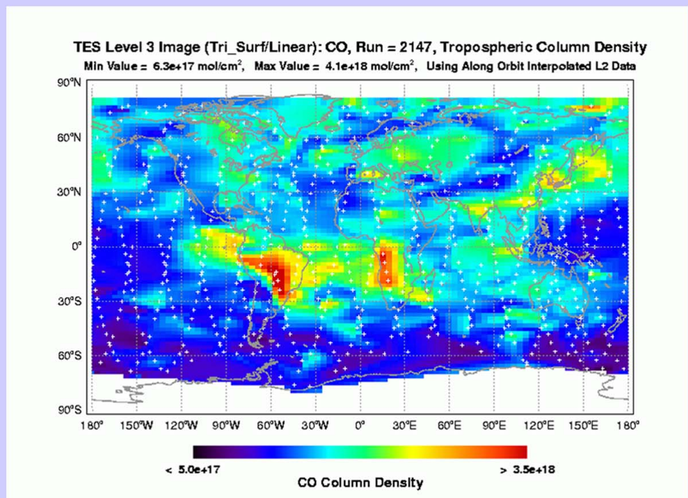
(2) Bottom panel: the reported total percent error for CO column as function of latitude for both instruments. The global average values are 8.7% for TES and 11.7% for MOPITT respectively. Both TES and MOPITT have reported geo-location dependent DOFs for CO profiles as 0.5 - 2.



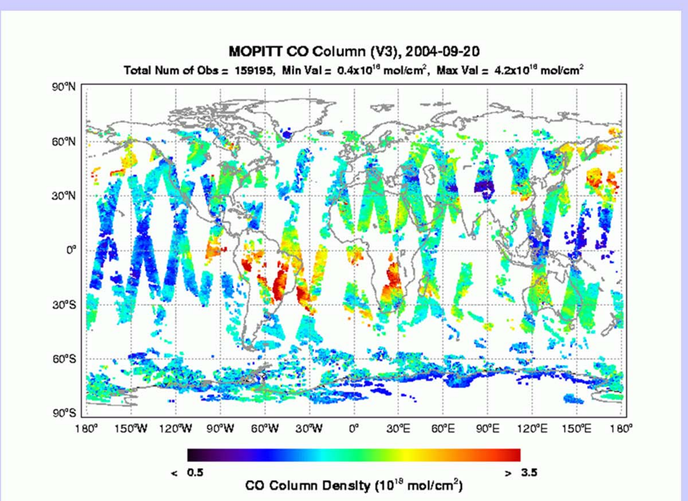
TES nadir retrieval results: 16-orbit global survey (~26 hrs) observation geo-locations colored by the CO tropospheric column. The footprints are enlarged. The actual size is 5 x 8 km. The enhanced CO in tropical S. America and Africa were observed.



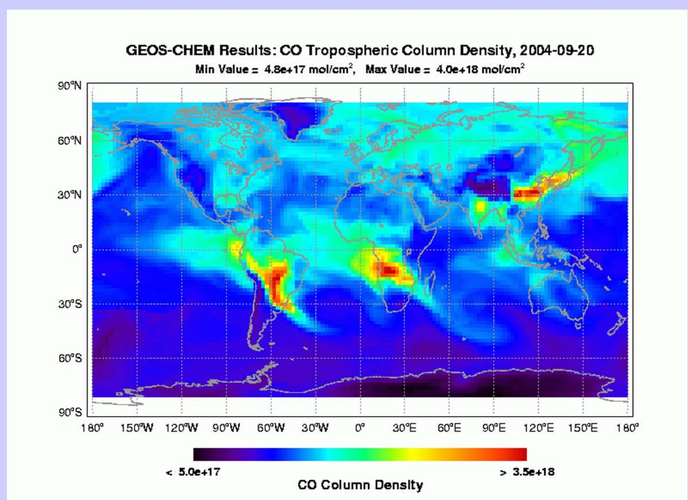
TES Level 3 browsing image for the global survey. A 2-D triangulate linear interpolation method is used. The white cross simbols illustrate the nadir targets of TES mesurements. Considerble gaps in time and space ocurr in the observations.



CO column products of MOPITT taken on the same day, 2004-09-20. The MOPITT footprint is 22x22 km. Similar sized dots are used at the observation geo-locations for the colored footprints. We conclude the TES and MOPITT show a similar global CO column distribution.



Harvard GEOS-CHEM model result for CO tropospheric column for the same day. Enhanced CO regions shown in both TES and MOPITT data are seen in the model.



5. Summary and Future Plans

- **Since succesefully launched on July 15, 2004, TES made routine global survey measurenets and some special observations to support validation activities. Data from a sample global survey and several special observations were processed to level 2 (species profile retrievals).**

- **TES team has been closely mornitoring the performances of the instrument and the time trends of the signal to noise ratios. Periodic decontaminations have reduced residual detector ice buildup. The 1A1 filter used to retrieve atmospheric CO is sensitive to instrument alignment which has seen stablized. The spikes shown in TES calibrated spectra occur at fixed frequences and are flagged in the L1B data.**

- **For nadir observations, scan-pixel-averaged spectra are used to retrieve CO profiles. The column densities of CO are retrieved to a precision of about 5-10%. The latitude-dependent degree of freedom of signal (DOFs) for the retrieved CO profiles are about 0.5 - 2, meaning TES measurements provide 0.5 to 2 pieces of independent vertical information for tropospheric CO. The better DOFs normally occure near the tropics and clear-sky conditions where fewer scan signals were rejected due to clouds.**

- **In a preliminary comparisons for day 2004-09-20, TES nadir measurements show similar regions of elevated CO over and near the coasts of S. America and Africa, consistent with the infrared column measurements with the MOPITT instrument during the time period. The Harvard GEOS-CHEM model also shows enhansed CO due to extensive biomass burnings in both regions.**

- **Future data validations will include comparisions of spectral radiances with those obtained from aircraft (e.g., S-HIS) and space (e.g., AIRS), the correlative profiles obtained from aircraft (e.g. AVE), ground-based solar occultation, surface in-situ sampling measurements in both hemispheres (e.g., CMDL), and the satellite (e.g., MOPITT, AIRS, ACE, MLS etc.)**

- **The TES limb measurements of CO using 1A1 filter are yet to be analyzed.**

http://tes.jpl.nasa.gov

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